Illinois Natural History Survey A Division of the Department of Energy and Natural Resources ENR

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21 August 1989

File Copy

Steve Gonzales
Illinois Dept. of Conservation
600 N. Grand Ave. West, Suite 3
Springfield, IL 62701

Dear Steve:

Please find enclosed the Segment Performance Report - FY 1989 for Waterfowl Surveys and Investigations (W-43-R (S1), Studies 101, 102, and 103.

Sincerely yours,

Stephen P. Havera

Stephen P. Havera
Director
Forbes Biological Station

SPH:kr

cc: Dennis Thornburg
Bill Anderson
Glen C. Sanderson

SEGMENT PERFORMANCE REPORT - FY 1989
Illinois Waterfowl Surveys and Investigations
Federal Aid in Wildlife Restoration
W-43-R (S1) - 37

Study 101 LEAD POISONING INVESTIGATIONS

Job 101.1 Incidence of Shot Ingestion in Mallards, Canada Geese, and Lesser Scaup.

This job was inactive during FY 1989 because additional data were not needed.

Job 101.2 Lead Poisoning in Mallards, Canada Geese, and Diving Ducks as Determined by Blood and Liver Chemistry.

This job was inactive during FY 1989 because additional data were not needed.

Job 101.3 Reports on Lead Poisoning.

A comprehensive manuscript was completed and published entitled, "Lead poisoning in Illinois waterfowl (1977-1988) and the implementation of nontoxic shot regulations." This manuscript includes a compilation of all of the data on abundance of spent shot in soil and sediment, ingested shot in gizzards, concentrations of lead and protoporphyrin in blood and/or liver, and lead poisoning die-offs, as collected in Illinois from 1977 to 1988. The manuscript also includes a documentation of nontoxic shot regulations in Illinois (past, present, and future), and how these regulations were impacted by legislative actions and lawsuits. This manuscript was published as an Illinois Natural History Survey Biological Note during FY 1989. A copy is attached.

In addition, a manuscript entitled "Effectiveness of selected lead and steel shot shells for dispatching crippled ducks" was published in the *Transactions of the Illinois Academy of Science*. A copy is also attached.

Study 102 SAMPLING WATERFOWL HUNTERS VIA MAIL-LETTER QUESTIONNAIRE

Job 102.1 Mail-Letter Questionnaire to Waterfowl Hunters.

The 1988 Illinois Waterfowl Hunting Questionnaire was sent to 4,007 systematically selected purchasers of the (1987) Illinois Migratory Waterfowl Stamp on 4 January 1988. As of 17 May 1989, 3,007 usable questionnaires were received for a response rate of 74%. A copy of the 1988 questionnaire (included with the preliminary report) is attached.

In addition, a systematically selected mailing list involving 4,000 purchasers of the (1988) Illinois Migratory Waterfowl Stamp was prepared for the 1989 Illinois Waterfowl Hunting Questionnaire.

Job 102.2 Reports on Results of Questionnaire.

A preliminary report on the results of the 1988 Illinois Waterfowl Hunting Questionnaire was prepared, a copy of which is attached.

Also the final report for the 1987 Illinois Waterfowl Hunting Questionnaire was prepared. This report was printed and distributed as Periodic Report No. 61, Waterfowl Program, Illinois Department of Conservation. A copy of this report is attached.

Study 103 HUMAN ACTIVITIES AND ECOLOGY OF DIVING DUCKS

Job 103.1 Disturbance of Diving Ducks on Pool 19 of the Mississippi River.

Extensive observations were made of diving ducks at each of 5 sites on Pool 19 during the fall and spring of 1986-87 and 1987-88. Data were recorded on the number of ducks, species composition, dominant activities, number of disturbances, time of disturbance, type of disturbance, the flushing distance of the birds from the disturbance, number of ducks disturbed, species composition of disturbed ducks, average altitude of disturbed ducks, what the ducks did as a result of the disturbance, and weather conditions. The findings of this study are included in the attached report.

Study 103 HUMAN ACTIVITIES AND ECOLOGY OF DIVING DUCKS

Job 103.1 Disturbance of Waterfowl on Keokuk Pool, Mississippi River

ABSTRACT

Human disturbance of waterfowl and coots was monitored during fall 1986 and 1987 and spring 1987 and 1988 on a 30-km segment of Keokuk Pool from Keokuk to Fort Madison, Iowa. High quality migration areas for diving ducks are limited and diving duck use of Keokuk Pool has been declining. Thirty-minute observations of waterfowl usage, human disturbance to waterfowl, and reaction of waterfowl to disturbances were conducted at five sites in a random sequence during morning and afternoon periods on weekdays, weekends, and holidays. Observations were taken for 124.5 hr in fall 1986, 123.5 hr in fall 1987, 75 hr in spring 1987, and 100.5 hr in spring 1988. A total of 110 disturbances were recorded for both falls and 92 were recorded for both springs. Boating activity associated with hunting was responsible for 30 and 42% of the disturbances during fall and the hunting seasons, respectively. Boating activity resulting from fishing caused 25, 14, and 39% and all boating activity 76, 78, and 63% of the disturbances in fall, hunting season, and spring, respectively. Waterfowl usage was highest at sites 4 and 5. However, the rates of disturbance (number of disturbances/observational hr) were also high at these sites. Site 5 had a disturbance rate of 1.01 times/hr for both falls and 1.00 time/hr for both springs. This rate would equate to approximately 11 disturbances/day during daylight hours in fall and 13 disturbances/day during daylight hours in spring. The overall disturbance rate for all sites was 0.44 time/hr (approximately 4.8 times/day during daylight hours) for both falls and 0.52 time/hr (6.8 times/day during daylight hours) for both springs. An experimental refuge inviolate to boating should be established where feasible between Nauvoo and Niota, Illinois, during fall and spring migration

periods and monitored for use by waterfowl, especially diving ducks.

Keokuk Pool is an important migration area for waterfowl, particularly diving ducks (Thompson 1973, Thornburg 1973, Serie et al. 1983, Serie and Sharp 1989). Continental population levels of lesser scaups (Aythya affinis), canvasbacks (A. valisineria), and redheads (A. americana) are below long-term averages and also below the goals established in the North American Waterfowl Management Plan (Kelly et al. 1989).

Human disturbance has affected the distribution and behavior of diving ducks on migration areas in the Mississippi Flyway (Evenson et al. 1973, Thompson 1973, Thornburg 1973, Korschgen et al. 1985, Kahl 1988). Wintering duck populations in the Atlantic Flyway (Cronan 1957, Sincock 1966, Morton et al. 1989) and in Europe (Hume 1976, Batten 1977, Tuite et al. 1983, 1984, Bell and Austin 1985, Cooke 1985, Edwards and Bell 1985, Cryer et al. 1987) have been affected by human disturbance. Fat deposition before and during migration is essential to satisfy the energetic requirements associated with the spring and fall flights (Kendeigh et al. 1977). Currently canvasbacks have few staging areas that provide abundant food resources (Korschgen et al. 1988).

Unfortunately human disturbance of diving ducks appears to be a problem on key migration areas. The wariness of lesser scaup to disturbance is largely unrecognized (Jessen 1981). Korschgen et al. (1985) estimated that canvasback staging on Lake Onalaska in Pool 7, a critical migration area of the Upper Mississippi River National Wildlife and Fish Refuge, left this staging area 19 times during the fall of study and may have expended up to 1 hr/day in flight as a result of disturbances. Kahl (1988) reported that boating disturbances on Lake Poygan, Wisconsin, caused canvasbacks to expend up to 9% more time foraging each day in spring and fall and possibly kept canvasbacks from having access to food resources for up to 63% of the daylight hours.

Serie and Sharp (1989) suggested, based on studies conducted on Pools 7 and 8 and Keokuk Pool, that fat reserves acquired by canvasbacks during fall stopover at these sites may be important in improving survival by conditioning the ducks for winter. Haramis et al. (1986) provided strong evidence that adult male canvasbacks with high relative early-winter body masses had both greater overwinter and annual survival probabilities. Morton et al. (1989) suggested that the physiological condition of wintering black ducks (Anas rubripes) was impaired by human disturbance resulting in reduced winter survival and/or nutrient reserves carried to the breeding grounds. Disturbance during spring migration is also undesirable. Energy reserves acquired on wintering and spring migration areas are used by ring-necked ducks (Aythya collaris) (Hohman et al. 1988) and canvasbacks (Barzen and Serie 1989) to meet reproductive demands.

Thornburg (1973) stated, "Eventually, restrictions on boating activity may be necessary in some areas, and the value and effectiveness of establishing a refuge on the Keokuk Pool should be thoroughly studied and seriously considered." The objectives of the current study were 1) to determine if human disturbance of waterfowl, particularly diving ducks, on Keokuk Pool is a problem during spring and fall migration; and 2) if disturbance is a problem, to suggest an area of the pool for consideration as a refuge.

ACKNOWLEDGEMENTS

We thank M. M. Georgi, L. R. Boens, R. D. Crompton, D. J. Holm, R. M. Whitton, and D. M. Day for assistance in conducting observations. M. M. Georgi and D. A. Todd

aided in data compilation; R. T. Shealy provided statistical support. G. C. Sanderson edited the manuscript.

METHODS

The study area consisted of a 30-km segment of Keokuk Pool stretching from Keokuk to Fort Madison, Iowa (Fig. 1). This stretch of the pool, described by Thompson (1973), has historically held the highest number of diving ducks (Thompson 1973, Thornburg 1973, Havera 1985). Based upon a pilot study conducted during fall 1985 and high-use areas of diving ducks found in previous studies (Thompson 1973, Thornburg 1973, Day 1984), five sites were selected to monitor waterfowl use and human disturbance (Fig. 1). Each site included the maximum amount of river area in which waterfowl could be identified and monitored with spotting scopes from the Illinois side of the river. Observations were conducted during the entire migration in fall (17 October-12 December 1986 and 16 October-29 December 1987) and spring (7 March-13 April 1987 and 25 February-12 April 1988). The majority of observations were conducted by the same two persons. Waterfowl populations were monitored by weekly aerial censuses during both falls and also during the spring of 1987. Ground counts were conducted during the spring of 1988. Peak population and use-day values (averages of successive counts multiplied by the number of days between the counts and summed over the migration period) were generated from the census data.

The 1986 Illinois waterfowl hunting season was 23 October-1 December. The 1986 Iowa waterfowl season was 20-22 September and 25 October-30 November for ducks and 4 October-12 December for geese. The 1987 Illinois waterfowl season was 22 October-30 November. The 1987 Iowa duck season dates were 19-21 September and 22 October-29 November. The 1987 Iowa goose season dates were 3 October-16 November for Canada geese and 3 October-11 December for snow geese. Illinois and Iowa had similar

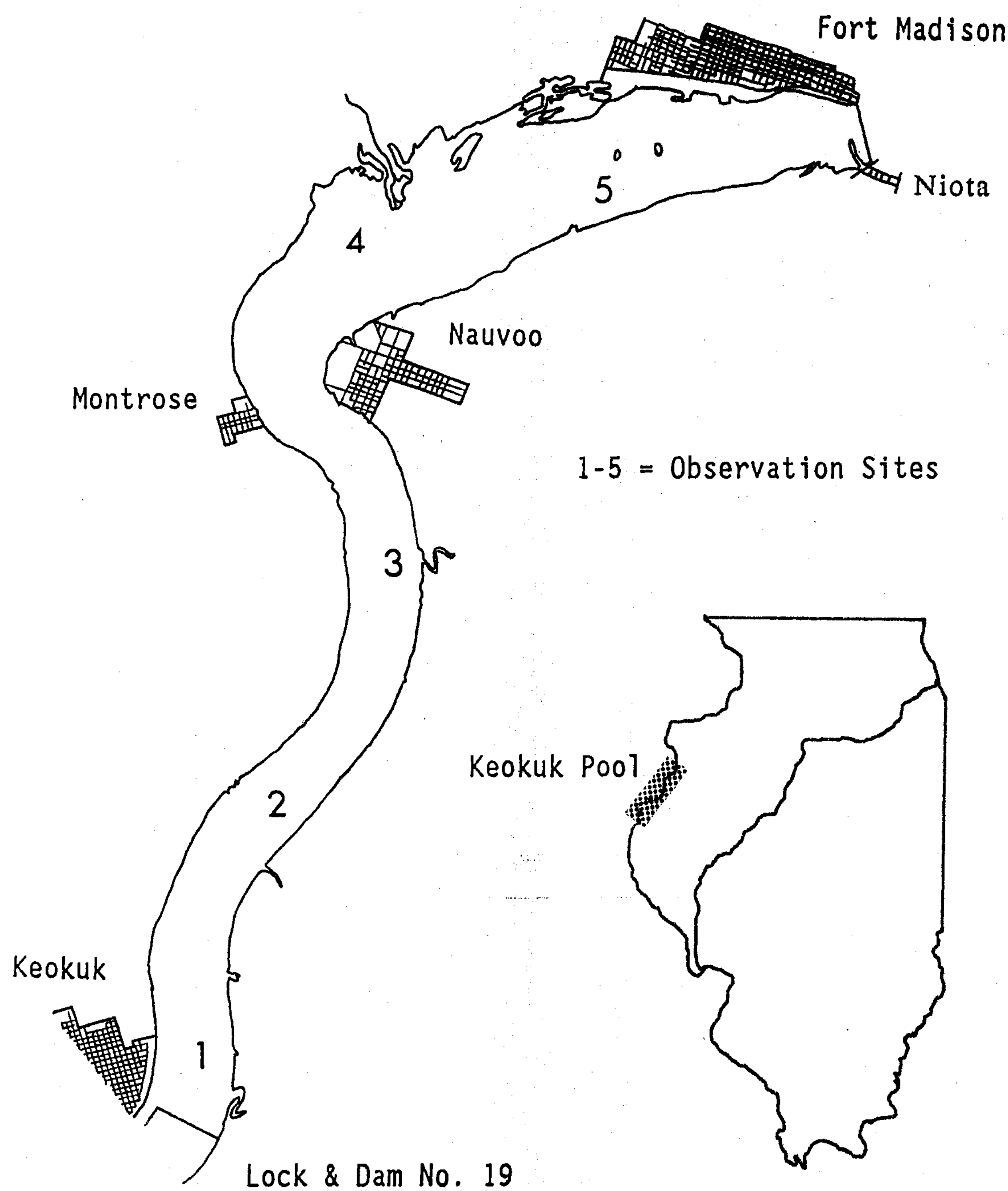

Fig. 1. Observation sites in the 30 km study area of Keokuk Pool used for monitoring disturbance of waterfowl from the Illinois shore.

hunting regulations in 1986 and 1987 with legal shooting time beginning at a half hour before sunrise and ending at sunset. Both states also used the point system for bag limits with the following values for the major species: mallard (Anas platyrhynchos) hen-100 and drake-35, lesser scaup-20, ring-necked duck-35, redhead-70, and canvasback-100 (closed in Iowa in 1986). The distributions of hunting blinds were plotted for 1986 (Fig. 2) and 1987 (Fig. 3).

The five sites were each monitored for 30 minutes in a randomly selected sequence during morning and afternoon observation periods. Two morning and two afternoon periods were selected in a random-stratified manner for observation during weekdays (Monday-Friday); one morning and one afternoon observation period were similarly selected on weekends. Observation periods with poor visibility were replaced with the next morning or afternoon interval that was not to be sampled. Because of the limited hours of daylight in fall and the time required to travel between the randomly selected sites, morning observation periods generally began within an hour of sunrise and afternoon observation periods began between noon and 1 p.m. Observations were also made during major holidays such as Veterans Day and Thanksgiving when greater hunting activity was likely to occur. In addition, observations were conducted during the opening days of the Illinois and Iowa waterfowl seasons. Four weekday (2 morning and 2 afternoon) and two weekend (1 morning and 1 afternoon) periods were also selected in a random-stratified manner for spring observations. In spring, when the amount of daylight was greater, initiation of observations varied randomly during the first 2 hours of light in the morning and the first 3 hours after noon.

Observations at each of five sites included the number of waterfowl, species composition, dominant activities (feeding/swimming, resting/sleeping, flying), number

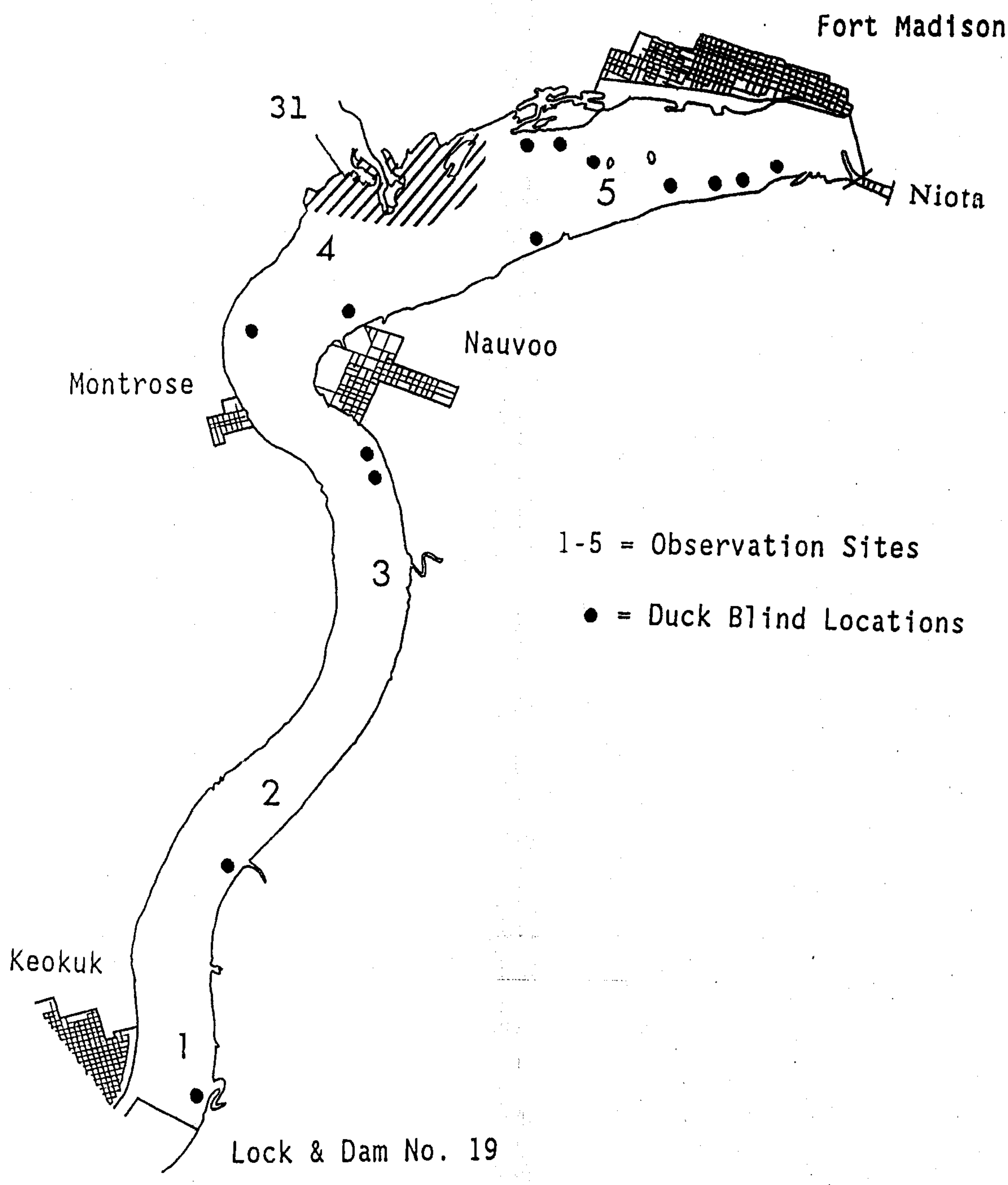

Fig. 2. Distribution of 45 waterfowl blinds in the study area in 1986. Thirty one blinds were located in the shaded Devil's Creek area between Montrose and Fort Madison, Iowa.

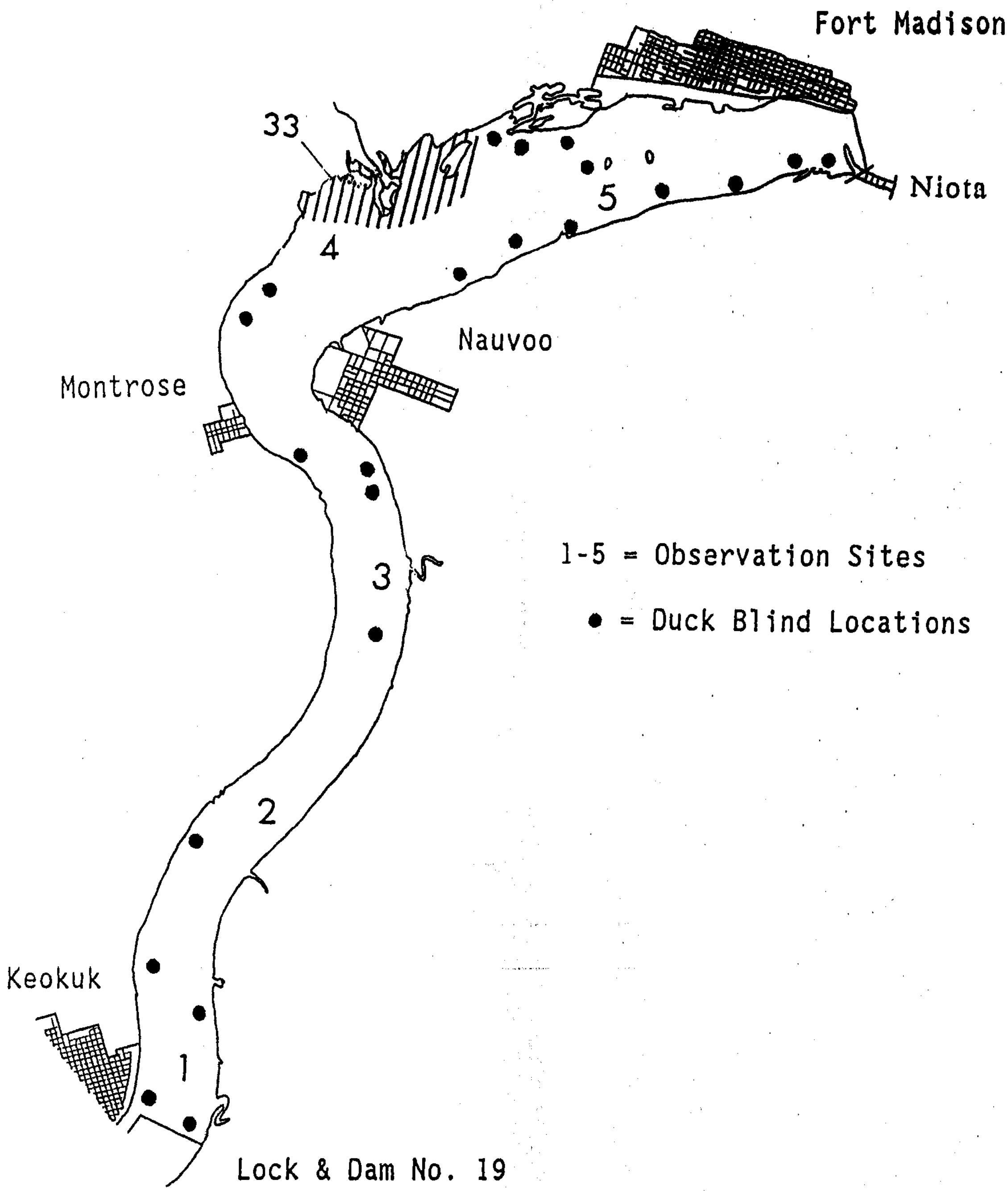

Fig. 3. Distribution of 55 waterfowl blinds in the study area in 1987. Thirty three blinds were located in the shaded Devil's Creek area between Montrose and Fort Madison, Iowa.

of disturbances, time of disturbance, type of disturbance, the flushing distance of the birds from the disturbance (estimated visually), number of waterfowl disturbed, species composition of the birds disturbed, behavior of the disturbed waterfowl (flew 0.8, 1.6 km or 3.2 km and landed, or flew out of sight), average flight time of disturbed waterfowl, average altitude of disturbed birds (estimated visually), and weather conditions. The study was not designed to provide quantitative data on activity budgets or differences in species tolerances to disturbances. Distance from the birds and visibility conditions often made identification of disturbed species in flight difficult. Therefore, data for disturbed birds were treated as a unit rather than by species. All birds at an observation site were considered as one flock.

A disturbance was any human activity causing waterfowl to fly. Disturbance was categorized into boating activities, barges, and shore activities (Table 1). Boats were generally assigned to one of the disturbance categories without difficulty. However, if classification as hunting or fishing activity was not clear, the type of boat involved was used for categorization (ie. jon boat). More than one disturbance from various factors occasionally occurred during a 30-minute observation period to part of the same flock of waterfowl. Sometimes the disturbed portion of a flock would react in more than one manner to the same disturbance. For example, part of the disturbed birds would fly 1.6 km and the remaining part would fly out of sight. In these cases the number of birds reacting differently were estimated and assigned to each of the behavior categories. Fifty observation periods representing 124.5 and 123.5 hr of actual monitoring were conducted in the falls of 1986 and 1987, respectively. Thirty observation periods comprising 75 monitoring hr were conducted in the spring of 1987, whereas, 40 observation periods encompassing 100.5 hr of observation were completed in the spring of 1988.

Table 1. Categories used for classification of human disturbances affecting waterfowl on Keokuk Pool.

Boating Activities:	Hunting	
		Hunters in boat
		Layout boat
	Fishing	
		Commercial fishing
		Sport fishing
	Other Boats	
		Speed (ski) boat
		Recreational (pleasure craft) boat
		Jon boat
		Sail boat
		Canoe
		Air boat
Barges		
Shore Activities:	People	
	Vehicle	
	Train	

The rates of disturbance for the falls and the springs were pooled for the purpose of presenting an overall view of the findings for this report. Because of its importance, this report will be revised for publication and subsequent statistical analyses may reveal that disturbance rates should be reported for each fall and each spring rather than combining the falls and the springs. Consequently, some of the numbers for disturbance rates in this report may be somewhat different than those presented in a subsequent publication, but the findings and recommendations should be similar.

RESULTS

The peak number, or highest number aerially inventoried on a given census during fall or spring, of ducks in the 30-km stretch of Keokuk Pool averaged 256,228 for the falls of 1986 and 1987, and diving ducks comprised 94.5% of this value (Table 2). For both springs, the peak number of diving ducks averaged 73,250, or 30.2% of the average peak for the falls. The most abundant diving duck in both the spring and fall was lesser scaup representing 55.6 and 58.1% of the average peak counts of diving ducks for fall and spring, respectively. Canvasbacks represented 39.0% of the average fall peak count for diving ducks and 31.1% of the average spring count.

An average of more than 9.212 million duck use-days were spent on the study area each fall and diving ducks represented 87.1% of this value (Table 3). Lesser scaups comprised 46.7% of the fall average of use-days for diving ducks whereas canvasbacks represented 33.8%. An average of approximately 1.627 million use-days were spent on the study area during both springs, which was 20.3% of the average value for diving ducks for both falls. Lesser scaups comprised 57.4% and canvasbacks represented 31.2% of the average total of diving duck use-days in spring.

Table 2. Peak numbers for waterfowl and coots on the Keokuk Pool from Keokuk to Fort Madison, Iowa, fall 1986 and 1987 and spring 1987 and 1988.

	Species									
Observation Seasons	Lesser Scaups	Canvasbacks	Ring-necked Ducks	Redheads	Total Diving Ducks	Mallards	Total Dabbling Ducks	Total Ducks	Total Geese	Coots
Fall 1986	131,000	86,000	21,500	12,500	216,600	8,400	15,285	230,470	2,075	121,800
Fall 1987	138,125	103,060	17,000	13,100	267,700	19,500	57,465	281,985	2,900	173,500
Average	134,563	94,530	19,250	12,800	242,150	13,950	36,375	256,228	2,488	147,650
Spring 1987	52,050	30,500	4,300	2,400	93,675	2,500	3,970	98,315	1,000	37,800
Spring 1988[a]	33,000	15,000	2,800	1,500	52,825					
Average	42,525	22,750	3,550	1,950	73,250					

[a] Based upon ground counts of diving ducks only.

Table 3. Use-days (in thousands) for waterfowl and coots on the Keokuk Pool from Keokuk to Fort Madison, Iowa, fall 1986 and 1987 and spring 1987 and 1988.

Observation Seasons	Species									
	Lesser Scaups	Canvasbacks	Ring-necked Ducks	Redheads	Total Diving Ducks	Mallards	Total Dabbling Ducks	Total Ducks	Total Geese	Coots
Fall 1986	3,345.9	2,607.4	533.9	346.7	7,464.2	396.4	653.3	8,228.2	72.4	2,621.4
Fall 1987	4,147.3	2,810.2	594.3	401.3	8,583.5	712.4	1,525.8	10,196.4	125.6	3,755.1
Average	3,746.6	2,708.8	564.1	374.0	8,023.9	554.4	1,089.6	9,212.3	99.0	6,376.5
Spring 1987	1,230.0	630.0	120.0	80.0	2,170.0	72.5	149.8	2,336.7	13.1	711.6
Spring 1988[a]	637.5	386.6	83.3	39.2	1,085.2					
Average	933.8	508.3	101.7	59.6	1,627.6					

[a] Based upon ground counts of diving ducks only.

The majority of the diving ducks, including both lesser scaups and canvasbacks, utilized the stretch of the study area between Montrose and Fort Madison, Iowa, which included observation sites 4 and 5 (Fig. 1). An average of 65.5% of the diving duck use-days in fall and 60.1% in spring occurred in this segment of the study area. The same pattern was shown for peak numbers. Sixty-seven percent of the fall and 60.6% of the spring peak number values for diving ducks occurred between Montrose and Fort Madison, Iowa.

The average number of waterfowl and coots per observation period at each monitoring site for both falls was highest at sites 4 and 5 (Table 4). These two sites also had the highest average number of birds per observation period in both springs. These findings are in agreement with the distribution of waterfowl documented in the censuses. Site 4 had a higher average number of waterfowl and coots per observation period in the fall (5,265) than in the spring (3,963), whereas, site 5 had a slightly higher number of birds in the spring (4,817 vs. 4,086). Site 2 had the fewest number of birds per observation period in both spring and fall.

Canvasbacks comprised from 22 to 24% of the waterfowl observed at each site during spring and fall, a fairly equal distribution among areas (Table 5). The percentage of lesser scaup among sites varied between 32% at site 1 and 47% at sites 3 and 5. However, the 36 and 24% values for lesser scaups and canvasbacks, respectively, at site 4 are probably low because 24% of the birds in this area were unidentifiable. Mallards were only seen in appreciable numbers at sites 1 and 2.

The dominant activity of waterfowl and coots at all sites in both spring and fall was feeding/swimming with an occurrence of 653 (77.1%) in 847 observations.

A total of 110 disturbances were recorded during fall, 65 in 1986 and 45 in 1987 (Table 6). For both falls, sites 4 and 5 incurred the most disturbances. Twenty-two

Table 4. Average number of waterfowl and coots per observation period at each site for fall 1986 and 1987 and spring 1987 and 1988.

	Observation Sites				
Observation Seasons	1	2	3	4	5
Fall	1,650	277	1,104	5,265	4,086
Spring	2,193	446	1,296	3,963	4,817

Table 5. Average estimated percent species composition at each observation site for all fall and spring observation periods, 1986-1988.

	Observation Sites				
Species	1	2	3	4	5
Scaup	32	37	47	36	47
Canvasback	22	23	25	24	23
Ring-necked	5	2	2	2	2
Goldeneye	2	5	6	3	4
Ruddy	5	1	2	1	2
Mallard	5	6	0	0	2
Coot	21	14	13	7	8
Unknown	5	2	1	24	5
Other	3	10	4	3	7

Table 6. Number of human disturbances, percentage of the total, and disturbance rate at each observation site for fall 1986 and 1987, spring 1987 and 1988, and fall and spring combined.

	Fall (n = 110)			Spring (n = 92)			Fall and Spring (n = 202)		
Observation Sites	No. of Disturbances	% of Total	Disturbances Per Observation Hour	No. of Disturbances	% of Total	Disturbances Per Observation Hour	No. of Disturbances	% of Total	Disturbances Per Observation Hour
1	9	8	0.18	3	3	0.08	12	5	0.14
2	16	15	0.32	14	15	0.40	30	15	0.36
3	13	12	0.26	23	25	0.66	36	18	0.42
4	22	20	0.44	17	19	0.49	39	19	0.46
5	50	45	1.01	35	38	1.00	85	42	1.01

disturbances occurred at site 4, 11 in each year, which represented 20% of all fall disturbances. Fifty disturbances, 32 in 1986 and 18 in 1987, representing 45% of the fall total, were recorded at site 5. The rate of disturbance, or number of disturbances/observation hr, ranged from 0.18 at site 1 to 1.01 at site 5 (Table 6). Thus, an average of one human disturbance of waterfowl occurred every 60 minutes of observation at site 5 during the falls of 1986 and 1987.

The disturbance rate for both falls at all sites was 0.44 time/hr; the rate during the hunting season was 0.46 time/hr, slightly higher than the 0.41 rate for the nonhunting period. The disturbance rate was 0.48 time/hr during morning observations in the falls and 0.41 time/hr for afternoon periods. During the hunting seasons, the disturbance rate was 0.55 time/hr for morning and 0.38 time/hr for afternoon observation periods.

Ninety-two disturbances occurred during both springs of the study, 46 in each year. Sites 3 and 5 had the most disturbances, representing 25 and 38% of the total, respectively (Table 6). The rate of disturbance ranged between 0.08 time/hr at site 1 to 1.00 time/hr at site 5. The disturbance rate for both springs for all sites was 0.52 time/hr, higher than the rate of 0.44 time/hr for the falls and 0.46 time/hr for the hunting seasons. The disturbance rate was 0.49 time/hr during morning observation periods in the springs and 0.56 time/hr during afternoon periods as compared with 0.48 and 0.41 times/hr for fall morning and afternoon periods, respectively.

For all fall and spring periods combined, 202 disturbances were recorded (Table 6). Eighty-five of the disturbances, or 42% of the total, were documented at site 5 for an overall disturbance rate of 1.01 times/hr. The disturbance rate for sites 2, 3, and 4 varied between 0.36 and 0.46 times/hr.

Twenty-six intentional disturbances were recorded at all sites, 18 during both falls for a disturbance rate of 0.07 time/hr and 8 in the springs for a rate of 0.05 time/hr. Intentional disturbances included hunting, fishing, and other boats deliberately passing through rafting ducks and barges blowing their horns to scare ducks. One case of hunters in two boats systematically harassing and shooting into a flock of ducks was documented.

Boating activities caused 76% of the waterfowl disturbances during fall, 78% during the hunting season, and 63% during spring (Table 7). Boating activities resulting from hunting represented 30% of all fall disturbances but 42% of the disturbances during the hunting season. Disturbances resulting from fishing boats decreased from 25 to 14% of the total during the hunting season but increased to 39% during spring. The percentage of total disturbances caused by other boating activities and by barges remained fairly constant, varying between 21 and 24% by other boating activities and 13 and 15% by barges, during the falls, hunting seasons, and springs. Disturbances on shore were highest in the springs because of increased bank fishing and the distribution of ducks closer to shore, which was probably a result of the absence of hunting. Not all boating, barges, and shore activities resulted in a disturbance. For example, there were 106 recorded activities that caused no disturbance in both falls, and 71 (67%) involved barges.

Boating activities represented 66, 69, and 62% of the fall disturbances at sites 1, 2, and 3, respectively, but 91% of the 22 disturbances at site 4 and 78% of the 50 disturbances at site 5 (Table 8). Boating activity associated with hunting was responsible for 68% of the disturbances at site 4 and 26% of the disturbances at site 5 during both falls. However, fishing was responsible for no disturbances at site 4 during fall but caused 44% of the disturbances at site 1. In the springs, boating

Table 7. Percentages of all disturbances of waterfowl and coots caused by human activity at all observation sites for fall 1986 and 1987, hunting season 1986 and 1987, and spring 1987 and 1988.

Type of Disturbance		Observation Seasons		
		Fall (n = 110)	Hunting Season (n = 76)	Spring (n = 92)
Boating Activities:	Hunting			
	Hunters in boat	26	37	
	Layout boat	4	5	
	Subtotal	30	42	
	Fishing			
	Commercial fishing	15	5	28
	Sport fishing	10	9	11
	Subtotal	25	14	39
	Other Boats			
	Speed boat	8	11	15
	Recreational boat	7	7	2
	Jon boat	4	1	4
	Sail boat	2	3	1
	Canoe			1
	Air boat			1
	Subtotal	21	22	24
Barges		13	14	15
Shore Activities:	People	5	3	14
	Vehicle	5	5	7
	Train			
	Subtotal	10	8	21

Table 8. Percentages of disturbances caused by human activity at each observation site for fall 1986 and 1987 and spring 1987 and 1988.

Types of Disturbance		Fall Observation Sites (n = 110)					Spring Observation Sites (n = 92)				
		1 (n = 9)	2 (n = 16)	3 (n = 13)	4 (n = 22)	5 (n = 50)	1 (n = 3)	2 (n = 14)	3 (n = 23)	4 (n = 17)	5 (n = 35)
Boating Activities:	Hunting	22	13	8	68	26					
	Fishing	44	31	39	0	28	67	29	26	59	40
	Other Boats	0	25	15	23	24	0	29	22	35	23
	Subtotal	66	69	62	91	78	67	58	48	94	63
Barges		0	13	31	9	12	0	14	9	6	26
Shore Activities		33	19	8	0	10	33	29	44	0	11

activities generated between 48% (site 3) and 94% (site 4) of the disturbances. Fishing activity represented 67% of only 3 disturbances at site 1, 59% of 17 disturbances at site 4, and 40% of 35 disturbances at site 5 during the springs.

Boating activity associated with hunting disturbed an average of 51% of the birds in the flocks encountered and each disturbance caused an average of 2,255 waterfowl and coots to take flight (Table 9). Hunting activity resulted in a higher number of birds taking flight per disturbance because most of the hunting disturbances occurred at sites 4 and 5, which held more waterfowl (Tables 4, 8). Boating activity associated with fishing disturbed an average of 71% of the birds in the flocks encountered in the falls but only 42% of the birds in the springs. Similarly, barges disturbed a smaller percentage of birds in the flocks encountered in the springs (16%) than in the falls (40%). However, barge disturbances in the springs affected more birds per engagement than in the falls (1,191 vs 297, respectively) because most barge disturbances in spring occurred at site 5 where a higher number of birds were located. Other boating activities resulted in a comparable percentage of birds disturbed in a flock and a similar average number of birds affected per encounter in the falls and in the springs.

Boating activities caused more than 50% of the birds disturbed to fly out of sight in the falls (Table 10). Birds disturbed by barges and shore activities, however, resulted in most of them flying approximately 0.8 km before landing. In contrast, the percentage of waterfowl and coots disturbed that flew out of sight in the springs was lower for every type of disturbance. Because of the long length of the study area, verification of premature migration of the birds flying out of sight was not possible.

As a result of the high percentages of birds flying out of sight and the inability to obtain accurate flight times for those birds, energetic costs of

Table 9. Percentages of waterfowl and coots in the flocks taking flight by 20% increments for each disturbance category at all observation sites during fall 1986 and 1987 and spring 1987 and 1988. The average number of waterfowl taking flight for each type of disturbance is in parentheses.

	Fall Types of Disturbance (n = 110)						Spring Types of Disturbance (n = 92)					
% of the Flock Taking Flight	Hunting (n = 33)	Fishing (n = 28)	Other Boats (n = 23)	Barges (n = 14)	Shore Activities (n = 12)	Average	Hunting	Fishing (n = 36)	Other Boats (n = 23)	Barges (n = 14)	Shore Activities (n = 19)	Average
0-20	27	11	26	36	58	27		47	52	71	37	50
21-40	18	14	13	21	0	15		19	0	14	11	12
41-60	15	14	30	14	0	16		3	4	7	5	4
61-80	9	4	4	7	0	6		0	9	7	0	3
81-100	30	57	26	21	42	36		31	35	0	47	30
Average	51 (2,255)	71 (1,141)	48 (806)	40 (297)	44 (364)			42 (987)	46 (983)	16 (1,191)	54 (577)	

Table 10. Percentages of waterfowl and coots that flew approximately 0.8 km, 1.6 km, 3.2 km, and out of sight by disturbance type for fall 1986 and 1987 and spring 1987 and 1988.

	Fall Types of Disturbance (n = 110)					Spring Types of Disturbance (n = 92)				
Approximate Flight Distance[a]	Hunting (n = 33)	Fishing (n = 28)	Other Boats (n = 23)	Barges (n = 14)	Shore Activities (n = 12)	Hunting	Fishing (n = 36)	Other Boats (n = 23)	Barges (n = 14)	Shore Activities (n = 19)
0.8 km	34	26	38	57	75		30	41	63	65
1.6 km	6	9	7	6	0		14	15	31	5
3.2 km	9	0	3	6	0		14	7	0	10
Out of sight	51	65	52	31	25		42	37	6	20

[a] Estimated visually.

disturbances were not calculated.

The average time in flight for a group of disturbed birds, the average flushing distance from the disturbance factor, and the average altitude of flight for the majority of disturbed birds were estimated. Although not precisely measured, combined averages of these estimates for all types of disturbances for the falls and springs indicate, along with the percentage of disturbed birds that flew out of sight (Table 10), that waterfowl may have been more sensitive to disturbance in the fall. The average time in flight, including those birds that flew out of sight, was 108 $\pm$ 387(SD) (n = 525) sec in fall and 56 $\pm$ 60(SD) (n = 380) sec in spring. The average flushing distance was 312 $\pm$ 377 m in fall and 177 $\pm$ 136 m in spring. The average altitude of flight was 118 $\pm$ 86 m in fall and 56 $\pm$ 56 m in spring.

DISCUSSION

Numbers of lesser scaups and canvasbacks utilizing Keokuk Pool increased during the 1960's (Fig. 4) after the demise of the Illinois River 160 km to the east (Mills et al. 1966). However, during the 1980s, the numbers of canvasbacks and lesser scaups stopping at Keokuk Pool during fall have been decreasing. The peak population counts of lesser scaups during fall 1988 was 88,850, the lowest number inventoried on the pool since 1949. Similarly, the peak number of canvasbacks on Keokuk Pool during fall 1988 was only 36,060, the lowest number since 1964. The amount of aquatic vegetation has been increasing since the mid-1970s (Steffeck et al. 1985), but dramatically so during this study. Beds of wild celery (*Vallisneria americana*) are now abundant. Yet peak population counts and use-days of canvasbacks are lower than when wild celery and other submerged aquatic plants were not nearly as prevalent.

Disturbance has been shown to affect waterfowl on migration areas. Korschgen et al. (1985) found that canvasbacks staging on Lake Onalaska were disturbed an average

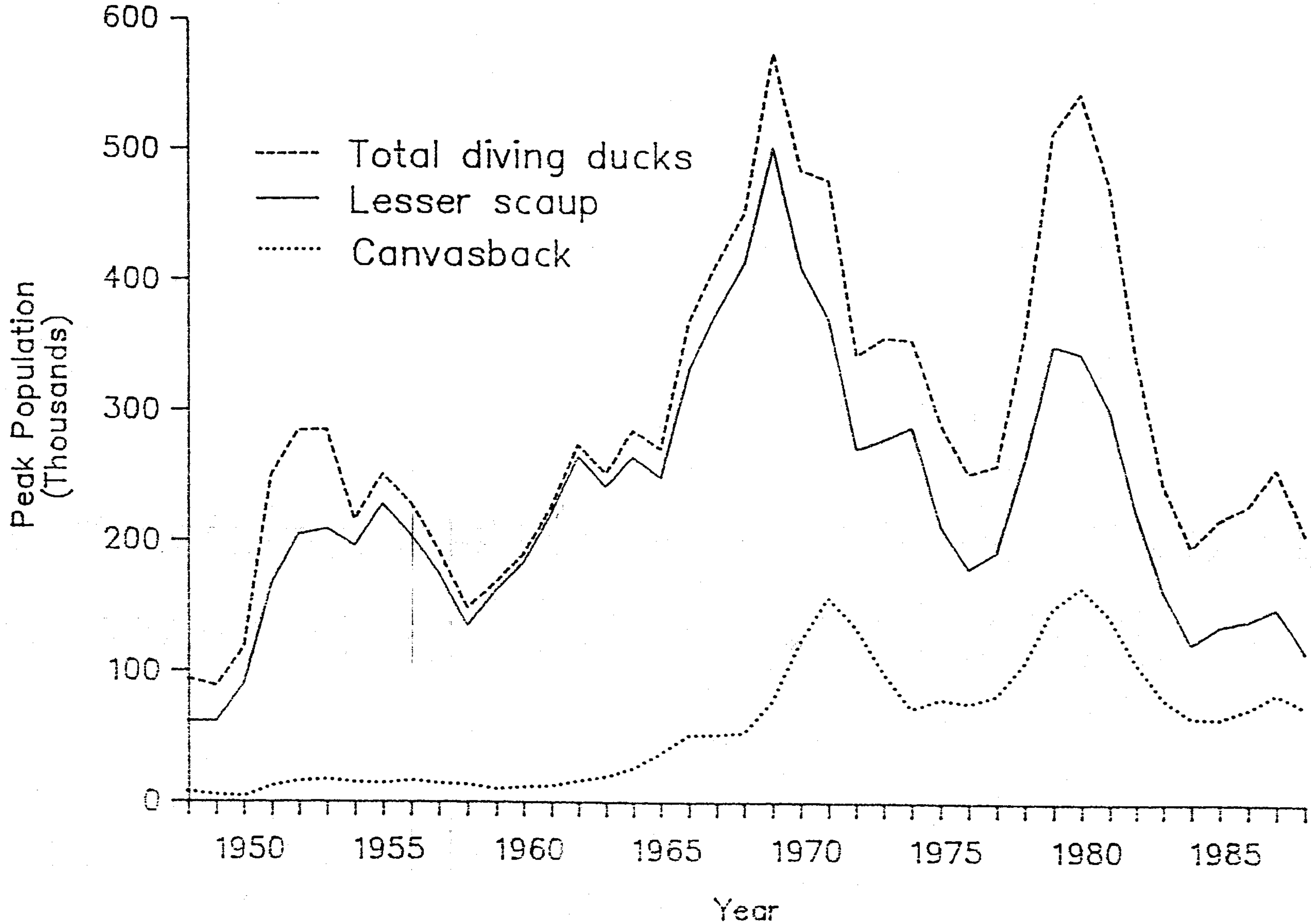

Fig. 4. Three-year moving averages of peak populations of lesser scaup, canvasback, and all diving ducks on Keokuk Pool, 1948-1988.

of 5.2 times/day resulting in a minimum flight time of 4.43 min/disturbance. Kahl (1988) reported that boating activities disturbed canvasbacks at Lake Poygan, Wisconsin, an average of 1.1 times/hr in each of 2 springs of monitoring and an average of 1.0 and 0.7 times/hr in 2 fall monitoring periods. Evenson et al. (1973) found that waterfowl, mainly diving ducks, were disturbed at a rate of 3.16 times/km^2/day on weekends and 2.12 times/km^2/day on weekdays during fall at Houghton Lake, Michigan. Disturbances at Houghton Lake averaged 1.52 times/day for each bird present during the hunting season. Belanger and Bedard (1989) documented a disturbance rate of 1.46 times/hr in fall and 1.02 times/hr in spring for greater snow geese (Chen caerulescens atlantica) staging in the Montmagny sanctuary, Quebec. Moreover, these authors noted that the level of disturbance on a given day in fall influenced goose use on the following day; a disturbance rate of greater than 2.0 times/hr resulted in a 50% reduction in the average number of geese present on the sanctuary the next day.

In his studies on Keokuk Pool from 1966-1968, Thompson (1973) noted that it was obvious that sections of the pool with greater human disturbance had lower use by ducks with 90% of the waterfowl concentrated on 28% of his study area during daytime. Thompson (1973) found a moderate rate of human disturbance of diving ducks in both spring and fall from Keokuk to Montrose (Fig. 1) and during spring from Montrose to Fort Madison. However, he found disturbance was common from Montrose to Fort Madison during fall, similar to findings in the current study (Table 6). Thornburg (1973) concluded that the distribution and movements of diving ducks on Keokuk Pool during fall were influenced by the abundance of benthic organisms and human disturbance, especially hunting activity. Thornburg (1973) noted that, unfortunately, food-rich areas, which included the Montrose to Fort Madison stretch, were highly disturbed resulting in mass movements of diving ducks at dawn to less productive areas in the Keokuk to Montrose segment with a return flight at dusk to the choice feeding areas. Other studies have shown that human disturbance affected feeding site selection and utilization by diving ducks (Cottam 1939, Cronan 1957, Sincock 1966, Dennis and Chandler 1974). In Britain, human disturbance has influenced the distribution of wintering ducks (Tuite et al. 1983, Cooke 1985, Cryer et al. 1987) and their premature departure from an area (Hume 1976, Bell and Austin 1985, Edwards and Bell 1987).

Korschgen et al. (1988) expressed concern that canvasbacks have few staging areas containing abundant food resources. Consequently, wise management of the remaining major migration areas, such as Keokuk Pool, is imperative. Korschgen et al. (1988) theorized that canvasbacks not acquiring sufficient energetic reserves for long-distance migration must remain in an area longer to gain sufficient energy reserves or make shorter migration flights. Serie and Sharp (1989) stated that the development of fat reserves by canvasbacks at migration sites appeared to be of more importance than just providing flight energies to reach wintering grounds. Serie and Sharp (1989) also noted that fat condition of birds seemed to have a major influence on the speed and timing of migration, population turnover, and was a function of the demand for nutrients at stopover sites. Haramis et al. (1986) further indicated that canvasback body mass in early winter was related to survival probability.

Day (1984) found that canvasbacks spent 29.8 and 37.8% of their time on Keokuk Pool diving in nonvegetated habitat during the springs of 1982 and 1983, respectively, as compared with a lower rate of 24.1% for fall 1982. Day (1984) reported that lesser scaups spent 26.4 and 44.9% of their time diving during the same two springs but dove at a lower rate of 15.8% during fall. Takekawa (1987) found that canvasbacks foraged 19.4% of the time spent during fall on Lake Onalaska while lesser scaups foraged 17.0% of the time. Comparatively, canvasbacks spent more time foraging on Keokuk Pool (24.1%) than on Lake Onalaska (19.4%) during fall while lesser scaups had more similar rates of foraging at both sites (17.0 and 15.8%, respectively).

In the present study, waterfowl were disturbed at a rate of 0.44 time/hr in fall and 0.52 time/hr in spring for all sites in the study area. Although the spring rate was slightly higher, the disturbed waterfowl appeared to react to a lesser degree in spring (Table 10). Unfortunately, the highest rates of disturbance for both spring and fall were at sites 4 (0.46/hr) and 5 (1.01/hr) (Table 6) where most of the waterfowl concentrated (Table 4). Given the rates of disturbance found in this study and the amount of time each day that diving ducks need to forage (Day 1984), it is possible that the recent decline in diving duck numbers on Keokuk Pool (Fig. 4) could be a result of disturbance. Korschgen et al. (1985) reported that because of an average disturbance rate of 5.2 times/day, diving ducks left the Lake Onalaska staging area 19 times during fall. With approximately 11 hr of daylight during fall (15 November) and 13 hr during spring (21 March), waterfowl were likely disturbed an average of 4.8 times/day at all sites and 11.1 times/day at site 5 during fall and an average of 6.8 times/day at all sites in spring and 13 times/day at site 5. While conducting a pilot study in fall 1985, we observed a flock of an estimated 120,000 diving ducks being disturbed by 8 different boats in 50 minutes at site 4. Disturbances of this magnitude and repeated intentional hazing of waterfowl flocks observed in this study and by G. C. Arthur (Ill. Dept. Conserv., retired, pers. commun.) obviously affect the feeding and resting behavior of diving ducks staging on Keokuk Pool. Correspondingly, accumulation of body fat (Serie and Sharp 1989) and potentially survival (Haramis et. al. 1986) can be detrimentally influenced.

MANAGEMENT IMPLICATIONS

The declining use of Keokuk Pool by diving ducks and the rate of disturbance documented in this study and in previous studies (Thompson 1973, Thornburg 1973) are cause for concern. Dahlgren (1988) in his literature review of human disturbances to migrating and wintering waterfowl noted that refuge was mentioned as the most common solution to disturbance problems. Indeed, Thornburg (1973) suggested that restrictions of boating activity in some areas of the pool may be necessary and the effectiveness of a refuge should be evaluated. Korschgen et al. (1985) offered that it may be important to manage current diving duck staging areas where disturbances can be controlled. Kahl (1988) remarked that management for restoration of migration areas for canvasbacks must include regulation of boating disturbance through spatial and temporal zoning. Other studies have recommended minimizing disturbance (Jessen 1981, Bergan et al. 1989) or establishing refuges (Tuite et al. 1983, Bell and Austin 1985, Cooke 1985) for staging or wintering diving ducks.

Options for reducing disturbance of waterfowl on Keokuk Pool include increased public awareness of the problem, increased law enforcement to reduce intentional disturbances, regulations restricting boating to a specified distance from rafting waterfowl, and establishment of a refuge inviolate to boating during migration periods. The present study and others (Batten ~~1977~~, ~~Hume~~ 1976, Mathews 1982) demonstrated that boating activity closer than approximately 450 m causes diving ducks to take flight. Four hundred and fifty meters is the minimum distance boating activity should be kept from rafting diving ducks. However, an inviolate refuge would likely be the most effective means of decreasing disturbance to waterfowl.

Establishment of an experimental inviolate refuge during spring and fall migration periods for a minimum of 2 years would help resolve the reason why diving duck numbers on Keokuk Pool are decreasing. The reason could be disturbance levels, changing habitat, lower continental population numbers, or a combination of these factors. If an inviolate refuge is established and monitored and numbers of diving ducks increase, then the factor is likely disturbance and the pool could be managed accordingly.

In this study, most of the diving ducks occurred between Montrose and Fort Madison, Iowa, which included observation sites 4 and 5 (Fig.1). Thompson (1973), Thornburg (1973), and Day (1984) also found high waterfowl use of this segment of the pool and also abundant waterfowl food resources. This stretch of the pool includes a variety of aquatic habitats, which are important for diving ducks because of the selection of different foraging sites (Siegfried 1976) and defense of foraging sites (Alexander and Hair 1979) among the various species.

Keokuk Pool is unique in that, except for the channel, the bottom of the pool is privately owned. Therefore, establishment of a large refuge would entail dealing with a multitude of landowners. However, Union Electric Company, Keokuk, Iowa, owns a large amount of the pool bottom in certain areas including north of Nauvoo, Illinois. The Illinois side of the pool from approximately river mile 378 north to river mile 383 owned by Union Electric and private citizens should be considered as a possible refuge area (Fig. 5). There are apparently fewer private leases and inholdings on the Illinois side of the channel in this area. Land ownership, which needs further investigation, will likely govern the actual size and location of the refuge. Citizens with property along the Illinois shore in the vicinity of river mile 379 to 380 will also need boating access to the river.

A refuge occupying part or most of the Illinois side of the river from mile 378 to 383 would include the area in the vicinity of observation site 5 (Fig. 5). If an experimental inviolate boating refuge were established in spring (15 February-25

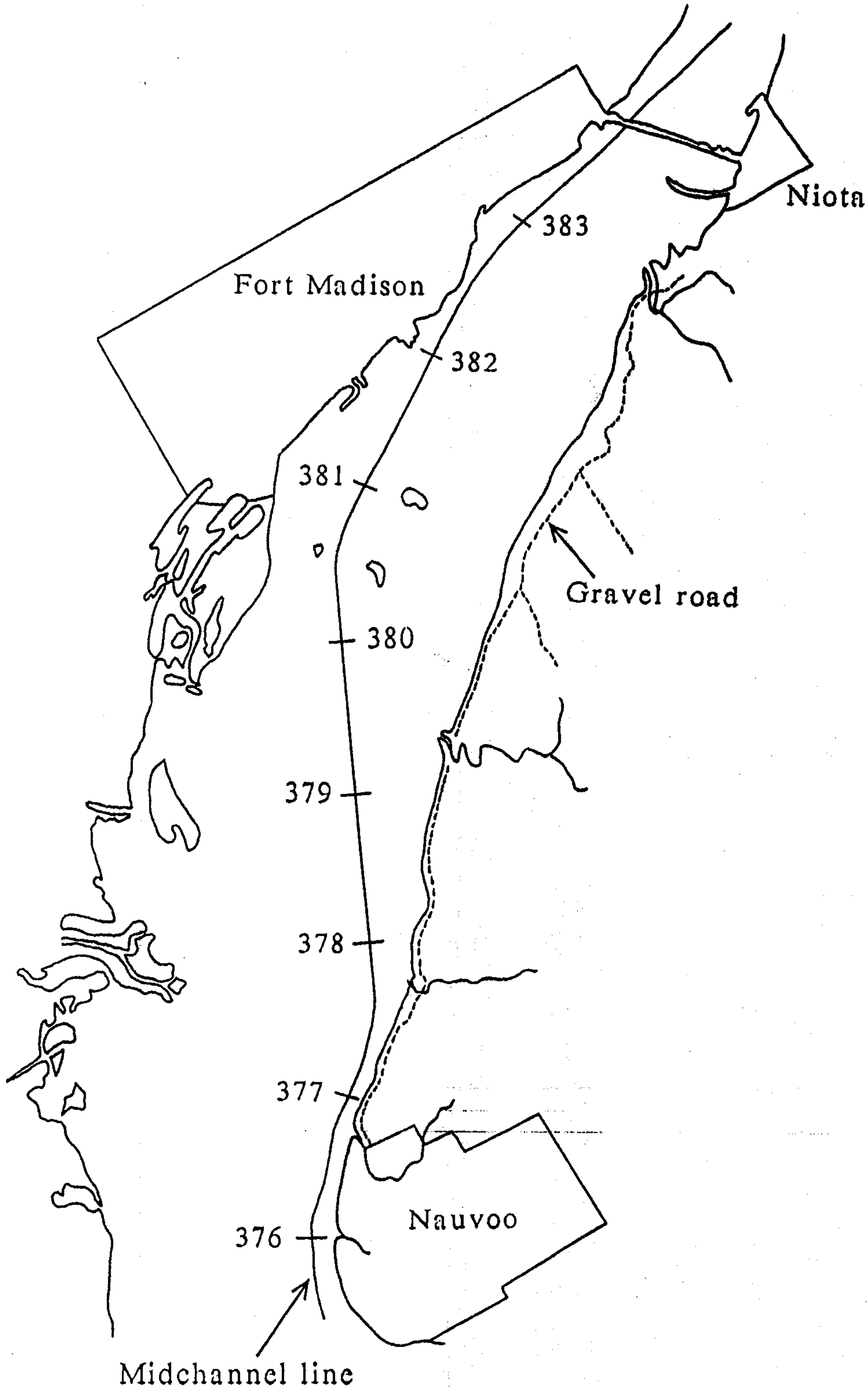

Fig. 5. Suggested area on Illinois side of channel between river miles 378 and 383 of Keokuk Pool for establishment of an experimental waterfowl refuge inviolate to boating from 15 October-15 December and 15 February-25 April. Actual refuge boundaries would be dependent upon land ownership and boating access.

April, Fig. 6) and fall (15 October-15 December, Fig. 7) in the area encompassing site 5 where an average of 1.01 disturbances/observation hr occurred (Table 6), then disturbances could potentially be reduced by 78% in fall and 63% in spring (Table 8). Barges would remain as a disturbance factor in this area, but barges appeared to have less effect on waterfowl than other disturbances (Table 10) and others have noted a reduced reaction by waterfowl to slower moving boats (Kahl 1988, Belanger and Bedard 1989, W. F. Nichols, private citizen, pers. commun.).

In consideration of the critical need of quality migration habitat for diving ducks (Korschgen et al. 1988), their declining use of Keokuk Pool, and the almost certain demand for increased boating recreation in the future, an experimental refuge inviolate to boating should be established in spring and fall on this crucial migration area.

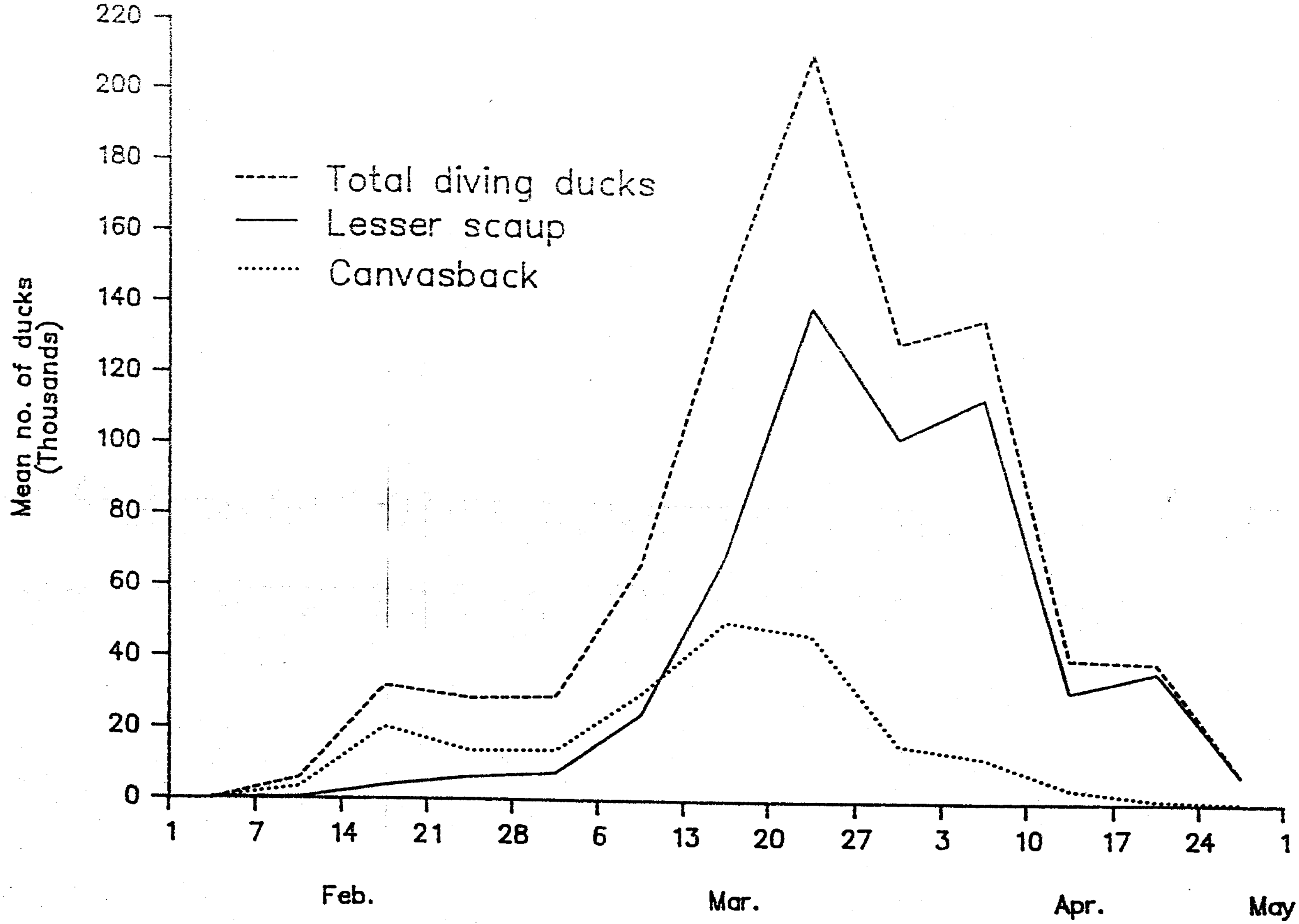

Fig. 6. Chronology of migration depicted by the average number of diving ducks, canvasbacks and lesser scaups per week utilizing the Mississippi River from Keokuk to Davenport, Iowa, during the springs of 1955-1962, 1967, 1974, 1976-1985, and 1987.

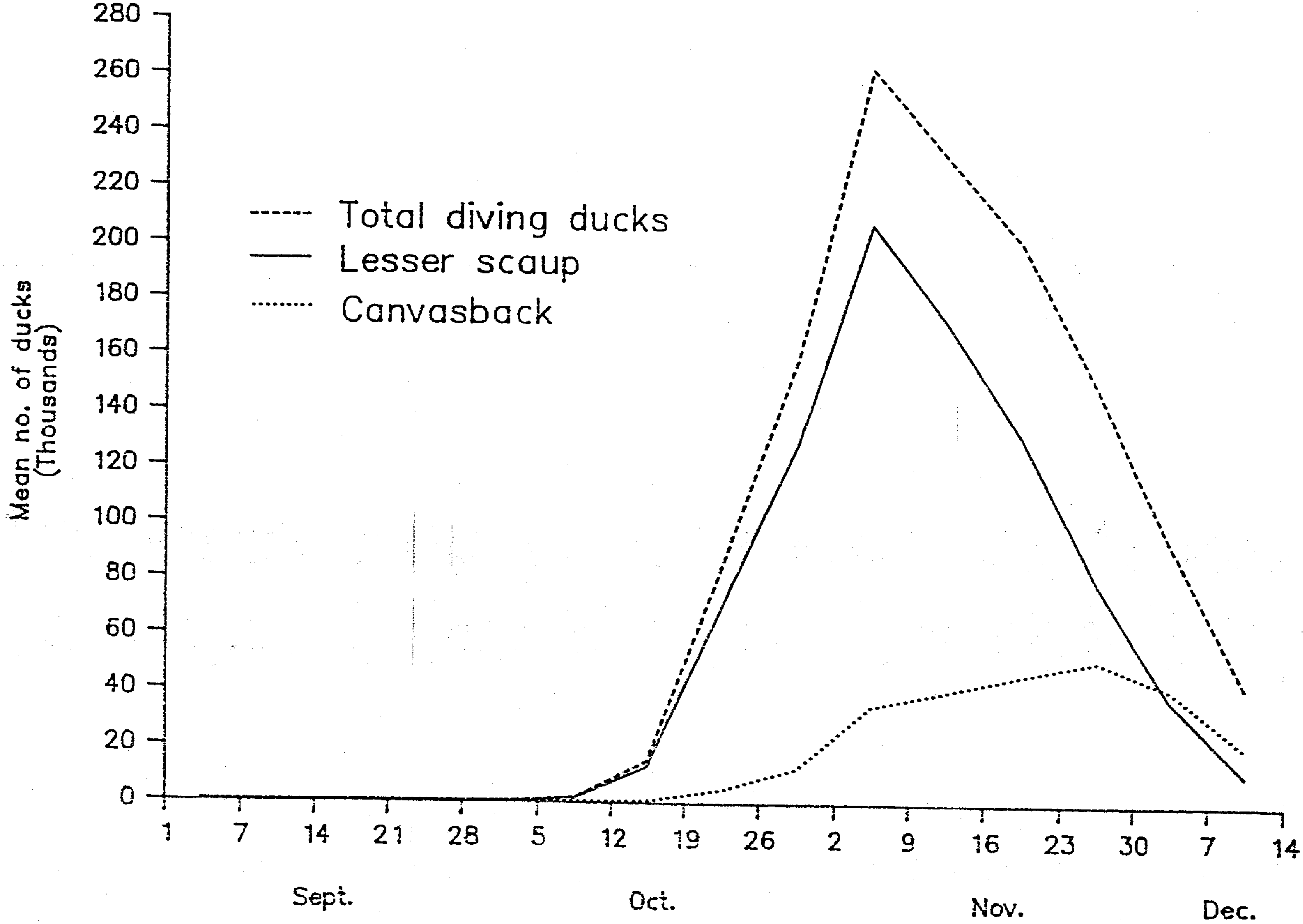

Fig. 7. Chronology of migration depicted by the average number of diving ducks, canvasbacks and lesser scaups per week utilizing the Mississippi River from Keokuk to Davenport, Iowa, during the falls of 1948-1988.

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